

# IGBT - SMPS

## 600 V, 40 A

### HGTG20N60A4

#### Description

The HGTG20N60A4 combines the best features of high input impedance of a MOSFET and the low on-state conduction loss of a bipolar transistor. This IGBT is ideal for many high voltage switching applications operating at high frequencies where low conduction losses are essential. This device has been optimized for fast switching applications, such as UPS, welder and induction heating.

#### Features

- 40 A, 600 V @  $T_C = 110^\circ\text{C}$
- Low Saturation Voltage:  $V_{CE(\text{sat})} = 1.8 \text{ V}$  @  $I_C = 20 \text{ A}$
- Typical Fall Time: 55 ns at  $T_J = 125^\circ\text{C}$
- Low Conduction Loss
- This is a Pb-Free Device

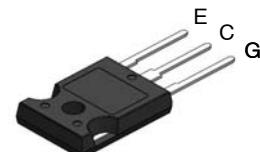
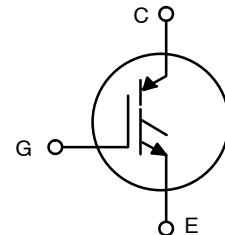
#### Applications

- UPS, Welder



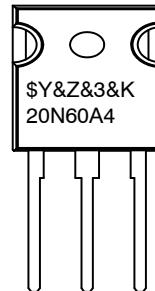
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TO-247-3LD  
CASE 340CK

#### MARKING DIAGRAM



\$Y  
&Z  
&3  
&K  
20N60A4

= ON Semiconductor Logo  
= Assembly Plant Code  
= Numeric Date Code  
= Lot Code  
= Specific Device Code

#### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

# HGTG20N60A4

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25°C, unless otherwise specified)

Parameter	Symbol	Ratings	Unit	
Collector to Emitter Voltage	BV <sub>CES</sub>	600	V	
Collector Current Continuous	T <sub>C</sub> = 25°C	I <sub>C</sub>	70	A
	T <sub>C</sub> = 110°C		40	A
Collector Current Pulsed (Note 1)	I <sub>CM</sub>	280	A	
Gate to Emitter Voltage Continuous	V <sub>GES</sub>	±20	V	
Gate to Emitter Voltage Pulsed	V <sub>GEM</sub>	±30	V	
Switching Safe Operating Area at T <sub>J</sub> = 150°C (Figure 2)	SSOA	100 A at 600V		
Power Dissipation Total	T <sub>C</sub> = 25°C	P <sub>D</sub>	290	W
Power Dissipation Derating	T <sub>C</sub> > 25°C		2.32	W/°C
Operating and Storage Junction Temperature Range	T <sub>J</sub> , T <sub>STG</sub>	-55 to +150	°C	
Maximum Lead Temperature for Soldering Leads at 0.063 in (1.6 mm) from Case for 10 s Package Body for 10 s, See Techbrief 334	T <sub>L</sub> T <sub>PKG</sub>	300 260	°C °C	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Pulse width limited by maximum junction temperature.

## PACKAGE MARKING AND ORDERING INFORMATION

Device	Device Marking	Package	Shipping
HGTG20N60A4	20N60A4	TO-247-3LD	450 / Tube

## ELECTRICAL SPECIFICATIONS (T<sub>C</sub> = 25°C, unless otherwise noted)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Collector to Emitter Breakdown Voltage	BV <sub>CES</sub>	I <sub>C</sub> = 250 μA, V <sub>GE</sub> = 0 V,		600	-	-	V
Emitter to Collector Breakdown Voltage	BV <sub>ECS</sub>	I <sub>C</sub> = -10 mA, V <sub>GE</sub> = 0 V		20	-	-	V
Collector to Emitter Leakage Current	I <sub>CES</sub>	V <sub>CE</sub> = 600 V	T <sub>J</sub> = 25°C	-	-	250	μA
			T <sub>J</sub> = 125°C	-	-	2.0	mA
Collector to Emitter Saturation Voltage	V <sub>CE(SAT)</sub>	I <sub>C</sub> = 20 A, V <sub>GE</sub> = 15 V	T <sub>J</sub> = 25°C	-	1.8	2.7	V
			T <sub>J</sub> = 125°C	-	1.6	2.0	V
Gate to Emitter Threshold Voltage	V <sub>GE(TH)</sub>	I <sub>C</sub> = 250 μA, V <sub>CE</sub> = 600 V		4.5	5.5	7.0	V
Gate to Emitter Leakage Current	I <sub>GES</sub>	V <sub>GE</sub> = ±20 V		-	-	±250	nA
Switching SOA	SSOA	T <sub>J</sub> = 150°C, R <sub>G</sub> = 3 Ω, V <sub>GE</sub> = 15 V, L = 100 μH, V <sub>CE</sub> = 600 V		100	-	-	A
Gate to Emitter Plateau Voltage	V <sub>GEP</sub>	I <sub>C</sub> = 20 A, V <sub>CE</sub> = 300 V		-	8.6	-	V
On-State Gate Charge	Q <sub>g(ON)</sub>	I <sub>C</sub> = 20 A, V <sub>CE</sub> = 300 V	V <sub>GE</sub> = 15 V	-	142	162	nC
			V <sub>GE</sub> = 20 V	-	182	210	nC
Current Turn-On Delay Time	t <sub>d(ON)I</sub>	IGBT and Diode at T <sub>J</sub> = 25°C, I <sub>CE</sub> = 20 A, V <sub>CE</sub> = 390 V, V <sub>GE</sub> = 15 V, R <sub>G</sub> = 3 Ω, L = 500 μH, Test Circuit (Figure 20)	-	15	-	ns	
Current Rise Time	t <sub>rl</sub>		-	12	-	ns	
Current Turn-Off Delay Time	t <sub>d(OFF)I</sub>		-	73	-	ns	
Current Fall Time	t <sub>fl</sub>		-	32	-	ns	
Turn-On Energy (Note 2)	E <sub>ON1</sub>		-	105	-	μJ	
Turn-On Energy (Note 2)	E <sub>ON2</sub>		-	280	350	μJ	
Turn-Off Energy (Note 3)	E <sub>OFF</sub>		-	150	200	μJ	

# HGTG20N60A4

## ELECTRICAL SPECIFICATIONS ( $T_C = 25^\circ\text{C}$ , unless otherwise noted) (continued)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Current Turn-On Delay Time	$t_{d(ON)I}$	IGBT and Diode at $T_J = 125^\circ\text{C}$ , $I_{CE} = 20 \text{ A}$ , $V_{CE} = 390 \text{ V}$ , $V_{GE} = 15 \text{ V}$ , $R_G = 3 \Omega$ , $L = 500 \mu\text{H}$ , Test Circuit (Figure 20)	–	15	21	ns
Current Rise Time	$t_{rl}$		–	13	18	ns
Current Turn-Off Delay Time	$t_{d(OFF)I}$		–	105	135	ns
Current Fall Time	$t_{rf}$		–	55	73	ns
Turn-On Energy (Note 2)	$E_{ON1}$			115	–	$\mu\text{J}$
Turn-On Energy (Note 2)	$E_{ON2}$		–	510	600	$\mu\text{J}$
Turn-Off Energy (Note 3)	$E_{OFF}$		–	330	500	$\mu\text{J}$
Thermal Resistance, Junction-Case	$R_{\theta JC}$		–	–	0.43	$^\circ\text{C}/\text{W}$

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

- Turn-Off Energy Loss ( $E_{OFF}$ ) is defined as the integral of the instantaneous power loss starting at the trailing edge of the input pulse and ending at the point where the collector current equals zero ( $I_{CE} = 0\text{A}$ ). All devices were tested per JEDEC Standard No. 24-1 Method for Measurement of Power Device Turn-Off Switching Loss. This test method produces the true total Turn-Off Energy Loss.
- Values for two Turn-On loss conditions are shown for the convenience of the circuit designer.  $E_{ON1}$  is the turn-on loss of the IGBT only.  $E_{ON2}$  is the turn-on loss when a typical diode is used in the test circuit and the diode is at the same  $T_J$  as the IGBT. The diode type is specified in Figure 20.

## TYPICAL PERFORMANCE CURVES (unless otherwise specified)

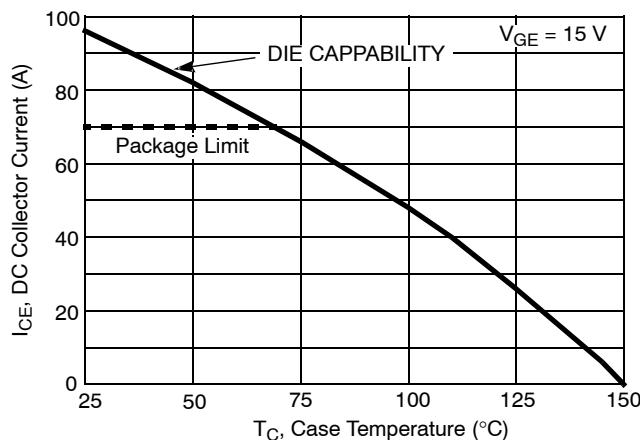


Figure 1. DC Collector Current vs. Case Temperature

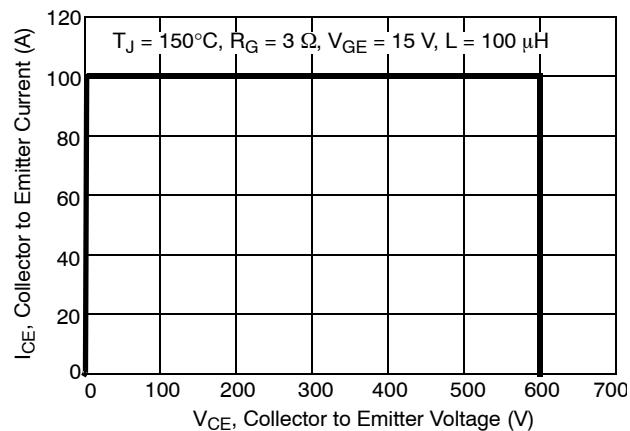


Figure 2. Minimum Switching Safe Operating Area

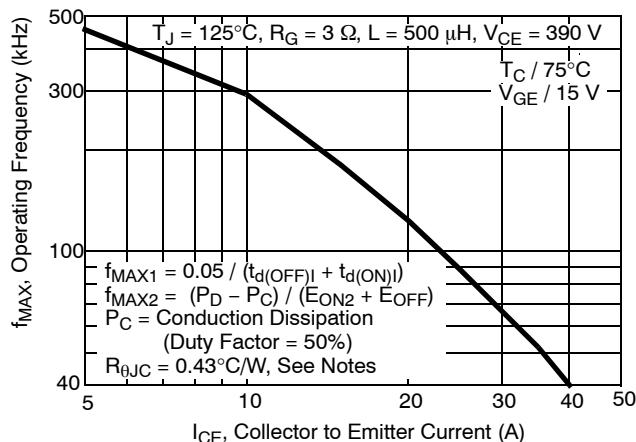


Figure 3. Operating Frequency vs. Collector to Emitter Current

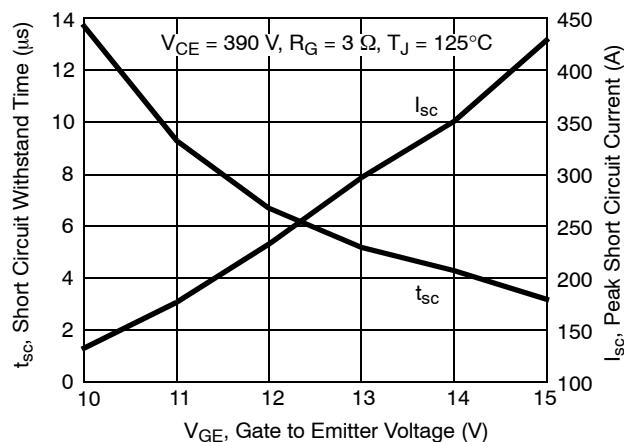


Figure 4. Short Circuit Withstand Time

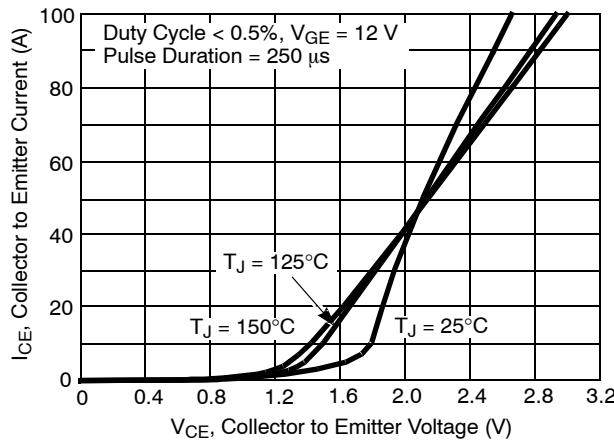


Figure 5. Collector to Emitter On-State Voltage

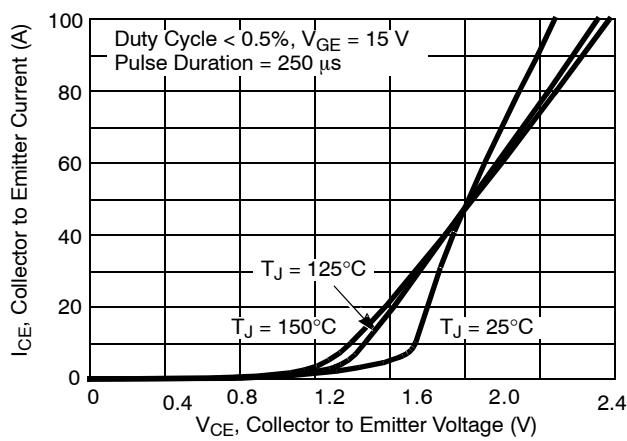
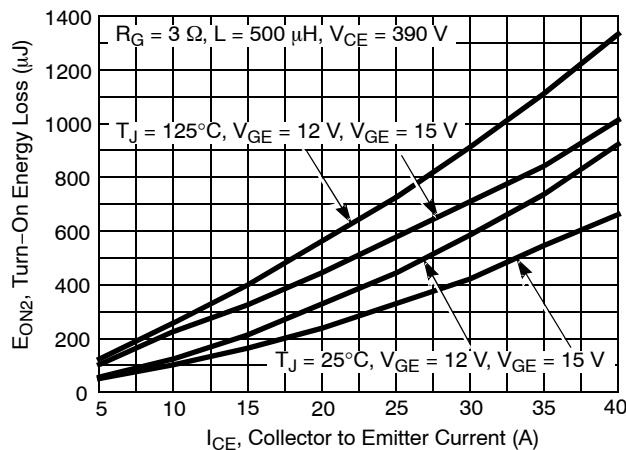
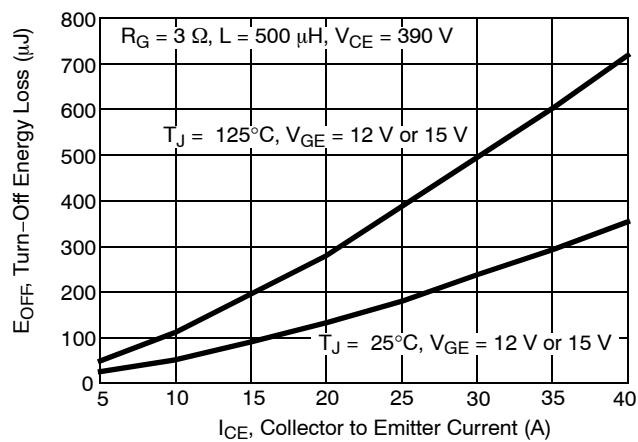


Figure 6. Collector to Emitter On-State Voltage

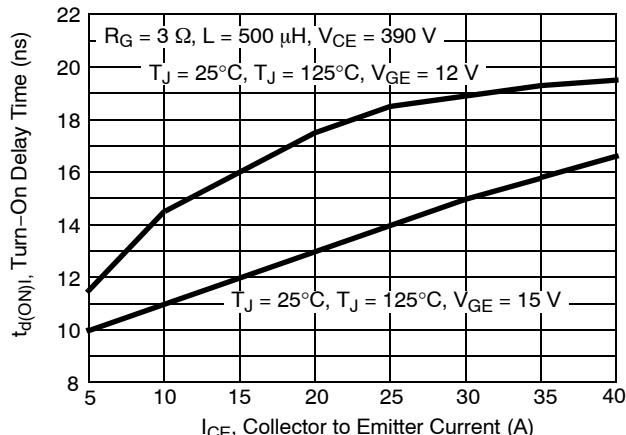
## TYPICAL PERFORMANCE CURVES (unless otherwise noted) (continued)



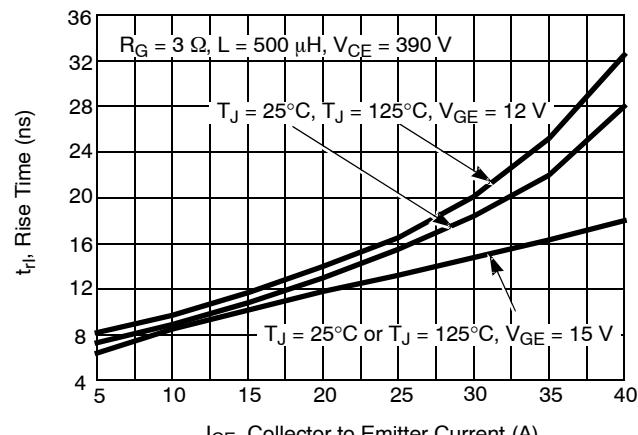
**Figure 7. Turn-On Energy Loss vs. Collector to Emitter Current**



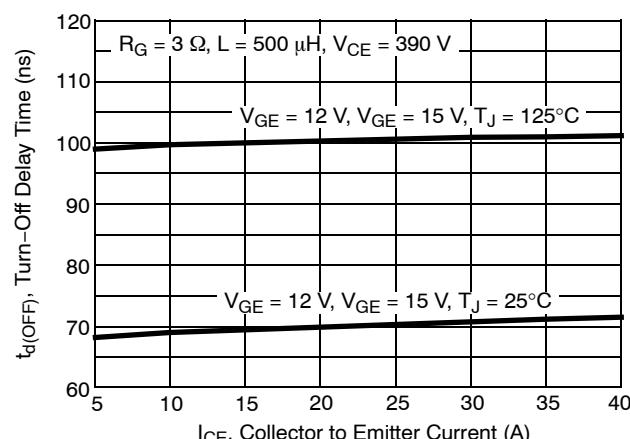
**Figure 8. Turn-Off Energy Loss vs. Collector to Emitter Current**



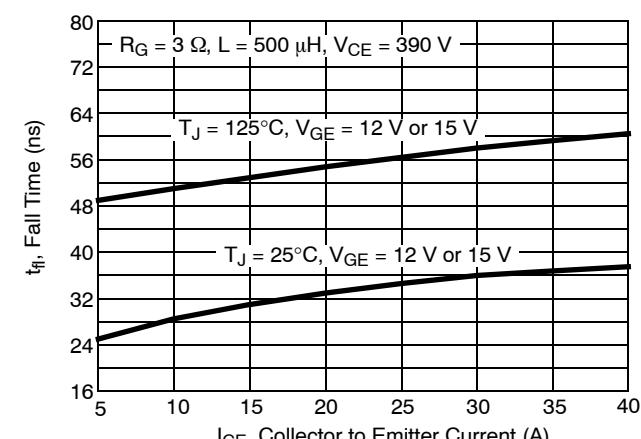
**Figure 9. Turn-On Delay Time vs. Collector to Emitter Current**



**Figure 10. Turn-On Rise Time vs. Collector to Emitter Current**



**Figure 11. Turn-Off Delay Time vs. Collector to Emitter Current**



**Figure 12. Fall Time vs. Collector to Emitter Current**

## TYPICAL PERFORMANCE CURVES (unless otherwise noted) (continued)

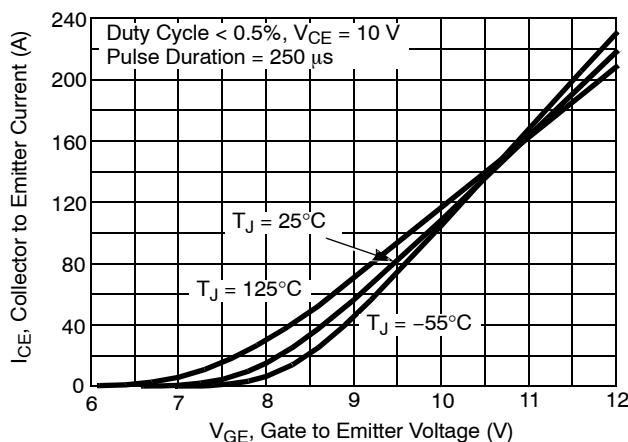


Figure 13. Transfer Characteristic

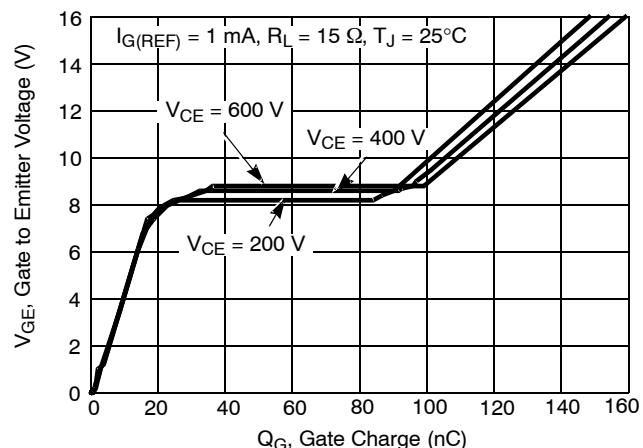


Figure 14. Gate Charge Waveforms

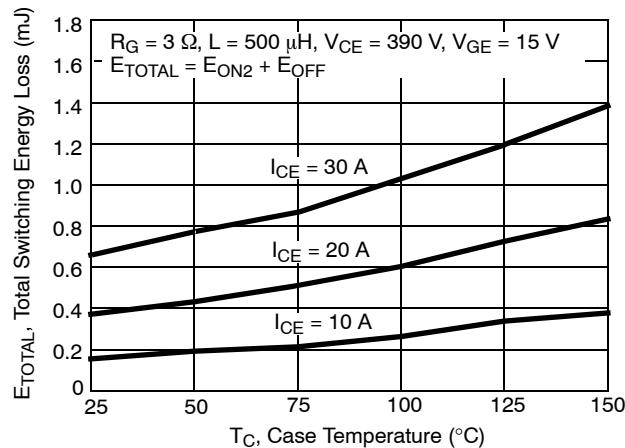


Figure 15. Total Switching Loss vs. Case Temperature

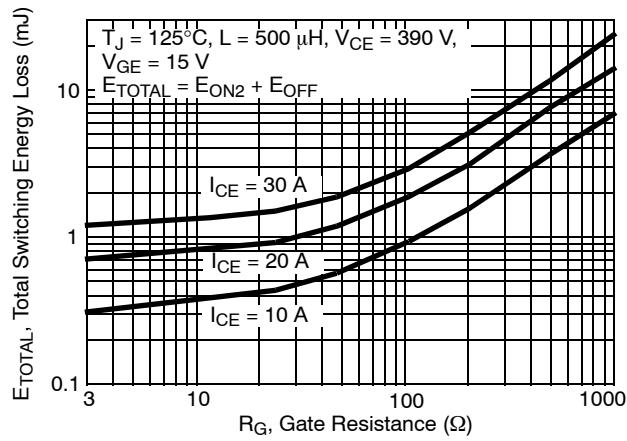


Figure 16. Total Switching Loss vs. Gate Resistance

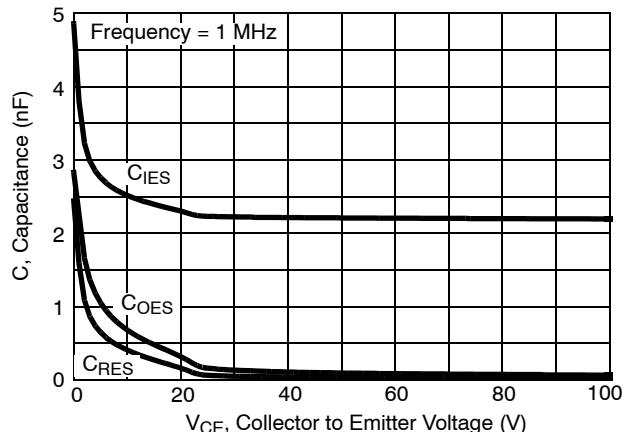


Figure 17. Capacitance vs. Collector to Emitter Voltage

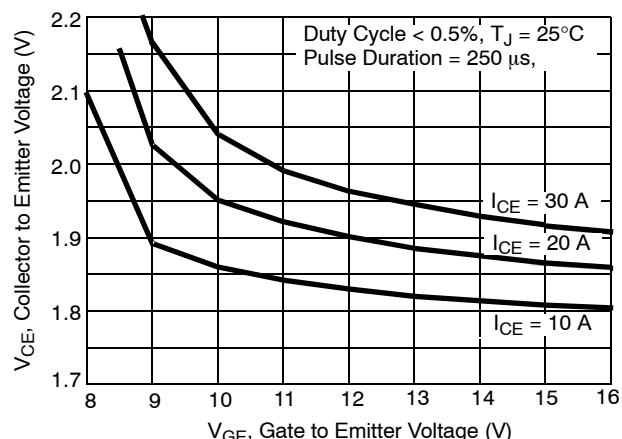


Figure 18. Collector to Emitter On-State Voltage vs. Gate to Emitter Voltage

## TYPICAL PERFORMANCE CURVES (unless otherwise noted) (continued)

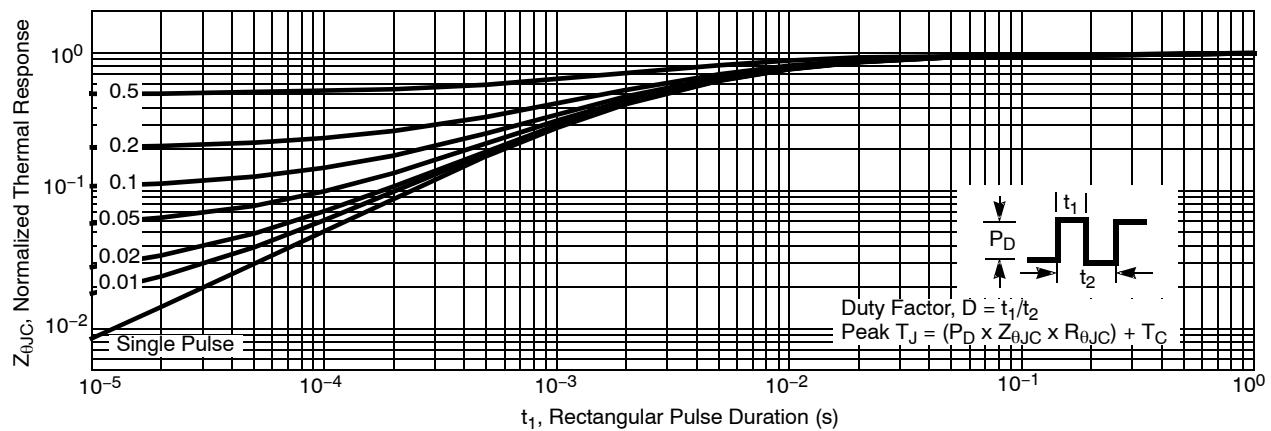


Figure 19. IGBT Normalized Transient Thermal Response, Junction to Case

## TEST CIRCUIT AND WAVEFORMS

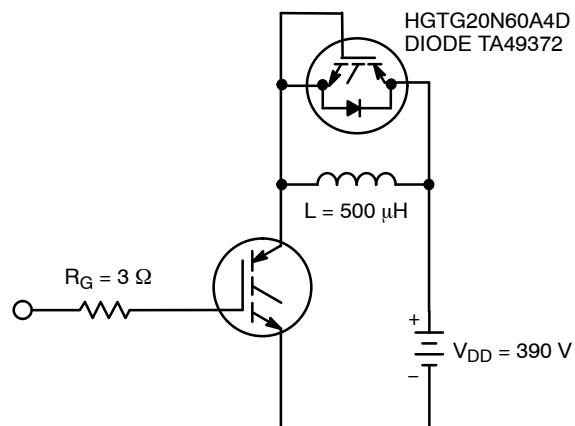


Figure 20. Inductive Switching Test Circuit

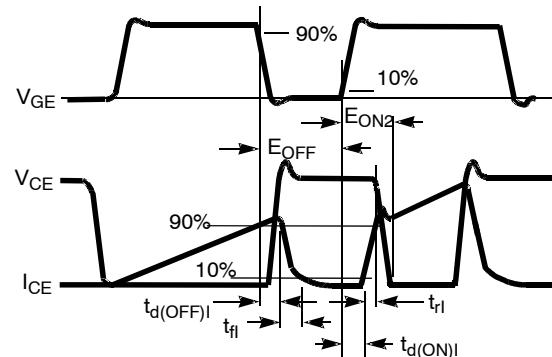


Figure 21. Switching Test Waveforms

## Handling Precautions for IGBTs

Insulated Gate Bipolar Transistors are susceptible to gate-insulation damage by the electrostatic discharge of energy through the devices. When handling these devices, care should be exercised to assure that the static charge built in the handler's body capacitance is not discharged through the device. With proper handling and application procedures, however, IGBTs are currently being extensively used in production by numerous equipment manufacturers in military, industrial and consumer applications, with virtually no damage problems due to electrostatic discharge. IGBTs can be handled safely if the following basic precautions are taken:

1. Prior to assembly into a circuit, all leads should be kept shorted together either by the use of metal shorting springs or by the insertion into conductive material such as "ECCOSORBD™ LD26" or equivalent.
2. When devices are removed by hand from their carriers, the hand being used should be grounded by any suitable means – for example, with a metallic wristband.
3. Tips of soldering irons should be grounded.
4. Devices should never be inserted into or removed from circuits with power on.
5. **Gate Voltage Rating** – Never exceed the gate-voltage rating of  $V_{GEM}$ . Exceeding the rated  $V_{GE}$  can result in permanent damage to the oxide layer in the gate region.
6. **Gate Termination** – The gates of these devices are essentially capacitors. Circuits that leave the gate open-circuited or floating should be avoided. These conditions can result in turn-on of the device due to voltage buildup on the input capacitor due to leakage currents or pickup.
7. **Gate Protection** – These devices do not have an internal monolithic Zener diode from gate to emitter. If gate protection is required an external Zener is recommended.

## Operating Frequency Information

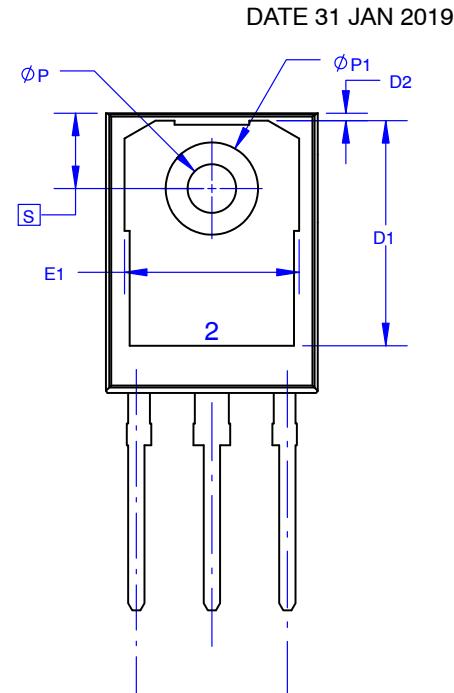
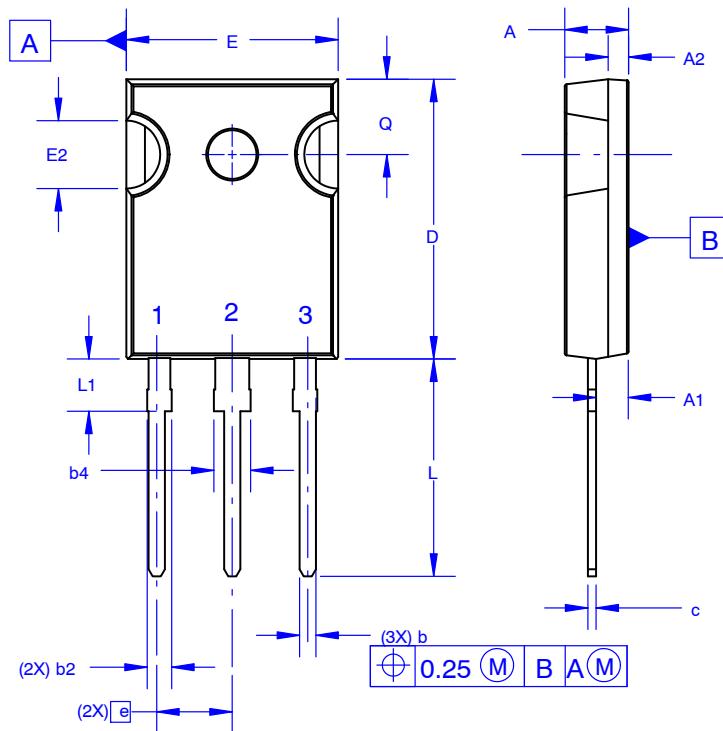
Operating frequency information for a typical device (Figure 3) is presented as a guide for estimating device performance for a specific application. Other typical frequency vs collector current ( $I_{CE}$ ) plots are possible using the information shown for a typical unit in Figures 5, 6, 7, 8, 9 and 11. The operating frequency plot (Figure 3) of a typical device shows  $f_{MAX1}$  or  $f_{MAX2}$ ; whichever is smaller at each point. The information is based on measurements of a typical device and is bounded by the maximum rated junction temperature.

$f_{MAX1}$  is defined by  $f_{MAX1} = 0.05/(t_{d(OFF)I} + t_{d(ON)I})$ . Deadtime (the denominator) has been arbitrarily held to 10% of the on-state time for a 50% duty factor. Other definitions are possible.  $t_{d(OFF)I}$  and  $t_{d(ON)I}$  are defined in Figure 21. Device turn-off delay can establish an additional frequency limiting condition for an application other than  $T_{JM}$ .

$f_{MAX2}$  is defined by  $f_{MAX2} = (P_D - P_C)/(E_{OFF} + E_{ON2})$ . The allowable dissipation ( $P_D$ ) is defined by  $P_D = (T_{JM} - T_C)/R_{θJC}$ . The sum of device switching and conduction losses must not exceed  $P_D$ . A 50% duty factor was used (Figure 3) and the conduction losses ( $P_C$ ) are approximated by  $P_C = (V_{CE} \times I_{CE})/2$ .

$E_{ON2}$  and  $E_{OFF}$  are defined in the switching waveforms shown in Figure 21.  $E_{ON2}$  is the integral of the instantaneous power loss ( $I_{CE} \times V_{CE}$ ) during turn-on and  $E_{OFF}$  is the integral of the instantaneous power loss ( $I_{CE} \times V_{CE}$ ) during turn-off. All tail losses are included in the calculation for  $E_{OFF}$ ; i.e., the collector current equals zero ( $I_{CE} = 0$ ).

TO-247-3LD SHORT LEAD  
CASE 340CK  
ISSUE A



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. DRAWING CONFORMS TO ASME Y14.5 - 2009.
- D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.
- E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

**GENERIC  
MARKING DIAGRAM\***



XXXX = Specific Device Code

A = Assembly Location

Y = Year

WW = Work Week

ZZ = Assembly Lot Code

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present. Some products may not follow the Generic Marking.

DIM	MILLIMETERS		
	MIN	NOM	MAX
A	4.58	4.70	4.82
A1	2.20	2.40	2.60
A2	1.40	1.50	1.60
b	1.17	1.26	1.35
b2	1.53	1.65	1.77
b4	2.42	2.54	2.66
c	0.51	0.61	0.71
D	20.32	20.57	20.82
D1	13.08	~	~
D2	0.51	0.93	1.35
E	15.37	15.62	15.87
E1	12.81	~	~
E2	4.96	5.08	5.20
e	~	5.56	~
L	15.75	16.00	16.25
L1	3.69	3.81	3.93
ØP	3.51	3.58	3.65
ØP1	6.60	6.80	7.00
Q	5.34	5.46	5.58
S	5.34	5.46	5.58

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